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NATICK/TR-82/042

DETERMINATION OF ENERGY CONSUMPTION OF FOOD SERVICE EQUIPMENT AT FORT DEVENS, MA

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This report provides the results of evaluating energy consumption of food service equipment in a real-life situation as requested by Troop Support Agency. Twenty-one items of equipment in three dining facilities at Fort Devens, MA were monitored for energy consumption; and one dining facility was monitored for total energy usage. The energy evaluation of individual pieces of equipment provides a comparison of equipment efficiency in energy utilization, while the collection of overall energy data of one dining facility provides a reference point from which the operating efficiency of other military

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dining facilities can be compared and rated.

SUMMARY

1. In response to the Troop Support Agency's request for energy assessment data of food service equipment operated in a real-life situation and to fulfill the requirement of A78-2F, entitled "Energy Efficiency Assessment", selected individual equipment in three dining facilities at Fort Devens were monitored for energy consumption. This report provides the data on and analysis of energy consumption of equipment designated by TSA in real-life situations. Types, models, and capacities of the equipment were identified. Energy costs were calculated based on per unit portion of foods prepared, such as cents per cup of coffee brewed and dispensed from a coffee urn, cents per serving of Salisbury steaks cooked in a convection gas oven, and cents per pound of ice cubes made by an ice maker, as requested by TSA.

2. From the test results, individual equipment can be compared for energy efficiency and cost of operation. Equipment that was poorly maintained consumed more energy than equipment that was relatively new and well maintained. Also, a large capacity equipment consumed less energy than a smaller one, per unit of food or drink prepared.

3. The tilt fry pan has been observed to be one of the most versatile equipment items in the kitchen. This was evidenced by the wide variety of foods cooked in different ways in the fry pan. Its energy consumption should be judged in light of its multi-usage capability.

4. In addition to the evaluation of individual equipment, one dining facility at Fort Devens was monitored for total energy consumption. These data are very valuable as they can be used as reference points from which the operating efficiency of other military dining facilities can be compared and rated.

PREFACE

As requested by the Troop Support Agency to evaluate individual food service equipment under a real-life situation, and to fulfill the DoD RDT&E Food Program A78-2F, selected equipment designated by TSA was monitored for energy consumption at Fort Devens, MA. The purpose is to provide energy data for Army's dining facility modernization program. Also, one dining facility was monitored for total energy consumption. These energy data include not only energy consumption of all the food service equipment in the dining facility, but also for auxiliary energy used for lighting, venting, cleaning, etc. This report summarizes energy consumption of individual equipment and also energy used for operating a military dining facility.

The authors would like to thank SP4 Gregory W. Ambrose for his efforts in recording a large volume of data in about three months at Fort Devens, MA, and also to Ms. Michelle Allain for her diligent effort in typing and preparing this manuscript.

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DETERMINATION OF ENERGY CONSUMPTION OF
FOOD SERVICE EQUIPMENT AT FORT DEVENS, MA

I. INTRODUCTION

The Food Engineering Laboratory of the US Army Natick Research and Development Laboratories (NLABS) was tasked by the Troop Support Agency (TSA) letter, DALO-TAE-T, 5 Oct 79, subject: Request for Energy Consumption Data, to determine the energy consumption of food service equipment in a real-world situation. Fort Devens was selected as the testing site. This task was also undertaken to fulfill the requirement of A78-2F, entitled "Energy Efficiency Assessment".

In response to TSA's request, items of equipment designated by TSA in three dining facilities at Fort Devens were metered for energy consumption. These three dining facilities were Bldg. 649, Bldg. 665, and Bldg. 657. One of the dining facilities, Bldg. 649, was also metered for total energy consumption. The metering of a whole dining facility provides data and information concerning the energy usage of total operation of the facility. Therefore, the energy data include not only the energy consumption for cooking and preparation of foods, but also for lighting, venting, cleaning, and performing other necessary tasks in the dining facility. The collection of the total energy data provides a basis of reference from which the operating efficiency of other dining facilities can be compared.

The measurements were taken in US Customary Units — the units built into the equipment by the manufacturers and generally understood by food service operators.

II. ENERGY CONSUMPTION OF INDIVIDUAL EQUIPMENT

Individual meters were installed on twenty-one items of equipment designed by TSA in three dining facilities at Fort Devens. Only one equipment, the beverage dispenser in Bldg. 649, could not be metered for energy consumption because it was inoperative. Energy consumption data of each piece of equipment are described and listed in Tables 1 to 11. For easy comparison, a summary of energy consumed and energy cost of all equipment evaluated is listed in Table 12. The pieces of equipment used are described in Appendix A.

A. Coffee Urns

Natural gas was used as the energy source by the coffee urns in each of the three dining facilities. When freshly brewed coffee was made, the brewing time usually was 10 to 20 minutes depending on the amount of coffee being made. The dispensing time and keeping the coffee warm when in use, was usually 2 to 3 hours. The data in Table 1 indicate that larger coffee urns (14-gal. capacity in Bldg. 649 and 665) consumed less energy per cup of coffee then the smaller urns (8-gal. capacity in Bldg. 657).

Table 1. Energy Consumption and Energy Cost of Coffee Urns

	Bldg. 649	Bldg. 665	Bldg. 657
. Type of Coffee Urn	Angelo-Colonna, twin-compartment	Angelo-Colonna, twin-compartment	Blickman, twin-compartment
. Urn holding capacity, gallons	14	14	8
. Energy in brewing, Btu/cup	94	77	108
. Energy in maintaining (keeping the urn warm when in use), Btu/cup	95	98	130
. Total energy (brewing & keeping warm), Btu/cup	189	175	238
. Total energy cost, ¢/cup	0.085	0.079	0.107

B. Convection Gas Ovens

Each convection gas oven monitored for energy consumption was equipped with a gas meter and an electric meter. The gas meter was used to measure the natural gas used by the oven burner, while the electric meter was used to measure the electricity used by the blower inside the oven.

During the data collection period, only one food item, namely Salisbury steaks, was cooked in all three dining facilities. By comparing the energy data collected and listed in Table 2, it appears that the convection oven in Bldg. 649 consumed more energy than those in Bldg. 665 and 657. The reason is probably due to the fact that the convection oven in Bldg. 649 was old and poorly maintained. The front panel used for shielding the burner flame was missing, causing the flame to burn in an unsteady, irregular, and vacillating manner.

Table 2. Energy Consumption and Cost of Operating Convection Gas Ovens

	Bldg. 649	Bldg. 665	Bldg. 657
1. Manufacturers	Franklin	Market Forge	Franklin
2. Burner Capacity, Btu/hr	60,000	80,000	60,000
3. Meatloaf, Btu/serving	798	565	—
Energy cost, ¢/serving	0.36	0.25	—
4. Salisbury Steak, Btu/serving	834	805	623
Energy cost, ¢/serving	0.38	0.36	0.28
5. Pork Roast, Btu/serving	—	816	707
Energy cost, ¢/serving	—	0.37	0.32
6. Stuffed Peppers, Btu/serving	522	468	—
Energy cost, ¢/serving	0.24	0.21	—
7. Potatoes (baked), Btu/serving	717	—	—
Energy cost, ¢/serving	0.32	—	—
8. Lasagna, Btu/serving	—	—	485
Energy cost, ¢/serving	—	—	0.22

C. Ice Maker

All ice makers in the three dining facilities make ice cubes. Each one had an electric meter installed for monitoring the electricity consumption. The ice makers in Bldg. 649 and 657 were new and had a larger capacity than the one in Bldg. 665. They were relatively more energy efficient per pound of ice produced than the one in Bldg. 665, as seen in Table 3.

Table 3. Energy Consumption and Cost of using Ice Makers

	Bldg. 649	Bldg. 665	Bldg. 657
1. Manufacturers	Scotman	Manitowac	Kold-Draft
2. Capacity, lbs of ice	500	250	450
3. Energy consumption, kWh/lb ice	0.16	0.18	0.16
4. Energy cost, ¢/lb ice	0.96	1.08	0.96

In 1974, NLABS contracted with the National Bureau of Standards to determine the energy efficiency on various type of ice makers. It was clearly shown that, based on per pound of ice produced, the cube ice requires one-third more energy than that of flake ice.

D. Frozen Food Cabinet

Each frozen food cabinet had a meter installed for monitoring the electric power consumption. In Bldg. 649, there was only one frozen food cabinet, Sub-Zero, whereas in Bldg. 665, there were two frozen food cabinets - Sub-Zero and Glenco. The Glenco had more than twice the volume as the Sub-Zero, and was relatively new. The Sub-Zero cabinet in Bldg. 649 was poorly maintained (the evaporator inside the cabinet was rusting), and since this was the only frozen food cabinet available in Bldg. 649, it was used more often (door openings) and its energy consumption was twice as much as the one in Bldg. 665, as shown in Table 4.

Table 4. Energy Consumption and Cost of using Frozen Food Cabinets

	Bldg. 649	Bldg. 665
1. Manufacturers	Sub-Zero	a. Sub-Zero b. Glenco
2. Cabinet, inside volume dimension, cubic feet	19.7	a. 19.7 b. 46.1
3. Energy consumption, kWh/day	8.4	a. 4.2 b. 15.5
4. Energy cost, ¢/day	50.4	a. 25.2 b. 93.0

E. Soda and Beverage Dispensers

For the same capacity, the soda dispenser used 0.6 kWh electricity per day more than the beverage dispenser, as shown in Table 5. This difference is probably because in a soda dispenser, a carbonator is used, whereas in a beverage dispenser, no carbonator is involved.

Table 5. Energy Consumption and Cost of using Soda and Beverage Dispensers

	Bldg. 665	Bldg. 657
1. Manufacturers	Cornelius Soda Dispenser	Jet Spray's Beverage Dispenser
2. Capacity, gallons	10	10
3. Energy Consumed, kWh/day	3.0	2.4
4. Energy cost, ¢/day	18.0	14.4

F. Tilt Fry Pan

This electrically heated tilt fry pan is a very versatile piece of equipment that can be used for cooking a variety of foods. Table 6 shows the energy consumption and cost for some foods commonly served in military dining facilities.

Table 6. Energy Consumption and Cost of using Tilt Fry Pan

	Bldg. 657
1. Manufacturer	Groen Model EPC-4
2. Electric rating, kW	14.3
3. French Toast, kWh/serving	0.04
Energy cost, ¢/serving	0.24
4. Fried Chicken Steak, kWh/serving	0.09
Energy cost, ¢/serving	0.54
5. Hash Browns, kWh/serving	0.05
Energy cost, ¢/serving	0.30
6. Pan Cakes, kWh/serving	0.04
Energy cost, ¢/serving	0.24
7. Fried Rice, kWh/serving	0.09
Energy cost, ¢/serving	0.54
8. Pork with Vegetables, kWh/serving	0.06
Energy cost, ¢/serving	0.36

G. Deep Fat Fryer

The deep fat fryer is heated by natural gas. French Fries and Southern Fried Chicken were the two most popular foods cooked in a deep fat fryer. As expected, the Southern Fried Chicken needs about four times more energy than the French Fries on a per-serving basis because of the much longer cooking

time required.

Table 7. Energy Consumption and Cost of Deep Fat Fryer

	Bldg. 657
1. Manufacturer	Vulcan-Hart, Model 61944
2. Btu rating, Btu/hr	65,000
3. Capacity, lb	20
4. French Fried potatoes, Btu/serving Energy cost, ¢/serving	183 0.08
5. Southern Fried Chicken, Btu/serving Energy cost, ¢/serving	791 0.36

H. Food Warming Cabinet

The food warming cabinet was heated by electricity. The energy consumption depends on the length of the time that the food is kept in the cabinet and the temperature of the food when it is first placed into the cabinet. The average time that the foods were kept in the food warming cabinet was 1.5 hours (Table 8).

Table 8. Energy Consumption and Cost of using Food Warming Cabinet

	Bldg. 657
1. Manufacturer	Franklin Model 1262-P, Twin Compartment
2. Electric rating, kW	2
3. Green Beans & Corn, kWh/serving Energy cost, ¢/serving	0.04 0.24
4. Mixed Vegetables, kWh/serving Energy cost, ¢/serving	0.04 0.24
5. Grits, kWh/serving Energy cost, ¢/serving	0.025 0.15

I. Soft Ice Cream Maker

Only one compartment (5-gal capacity) of each soft ice cream maker was monitored for energy consumption. It consumes 4.2 kWh of electricity per day when in use (Table 9).

Table 9. Energy Consumption and Cost of using Soft Ice Cream Maker

	Bldg. 645
1. Manufacturer	Taylor Freezer, Model 777-27, 2 compartments
2. Capacity	5-gal. capacity for each compartment
3. Soft Ice Cream (5-gal), kWh/day Energy cost, ¢/day	4.2 25.2

J. Steam Cooker

In steam cooking, the amount of energy required is below 100 Btu/serving as shown in Table 10, whereas cooking in a gas oven, the energy required is usually above 500 Btu/serving as shown in Table 2. The cost of energy in cooking is also considerably lower in steam cooking then in gas cooking, although it is recognized there were different types of foods cooked in these two kinds of equipment. Using exactly the same kind of foods, Swift and et. al.[1] have also concluded that in using five types of equipment, the cost of energy per pound of food in a steam cooker was the lowest.

Table 10. Energy Consumption and Cost of Operating Steam Cooker

	Bldg. 649
1. Manufacturer	Market Forge, Model 2W-2S 3 Compartments
2. Steam rating, lb/hr	266
3. Stewed Tomatoes, Btu/serving	33
Energy cost, ¢/serving	0.015
4. Cauliflower, Btu/serving	41
Energy cost, ¢/serving	0.018
5. Rice, Btu/serving	92
Energy cost, ¢/serving	0.041
6. Egg (for egg salad), Btu/serving	62
Energy cost, ¢/serving	0.028

[1] J. Swift, S. F. Conca, and J. M. Tuomy. Efficiency and Cost Factors in Rethermalizing Frozen Foods in Typical Dining Hall Equipment. Technical Report NATICK/TR-78/014, January 1978.

K. Steam Jacket Kettle

Cooking gravy and soup used much less energy than that used for potatoes and macaroni and chili. This is understandable that both potatoes and macaroni and chili are thicker products and their heat transfer is undoubtedly slower than gravy and soup as shown in Table 11.

Table 11. Energy Consumption and Cost of Steam Jacket Kettle

	Bldg. 649
1. Manufacturer	Legion Utensil Co.
2. Capacity, gallons	1 40-gal. kettle and 2 60-gal. kettle connected together, with 1 shut-off valve installed for each kettle
3. Macaroni & Chili, Btu/serving	82
Energy cost, ¢/serving	0.040
4. Vegetable Soup, Btu/serving	65
Energy cost, ¢/serving	0.029
5. Noodles in Water, Btu/serving	71
Energy cost, ¢/serving	0.032
6. Gravy, Btu/serving	61
Energy cost, ¢/serving	0.027
7. Potatoes, Btu/serving	128
Energy cost, ¢/serving	0.058

L. A Summary of Energy Consumption and Energy Costs of all Equipment

For easy comparison of the amount of energy consumed and energy costs of all equipment evaluated, Table 12 summarizes all the essential data. When making an equipment selection, refer to the comments made on the main body of this report for more information.

Table 12. A Summary of Energy Consumption and Energy Cost of all Equipment Evaluated

	Energy Consumed	Energy Cost
1. Coffee Urns, Coffee brewed and dispensed.		
Angelo-Colonna (Bldg. 649)	189 Btu/cup	0.085 ¢/cup
Angelo-Colonna (Bldg. 665)	175 Btu/cup	0.079 ¢/cup
Blickman (Bldg. 657)	238 Btu/cup	0.107 ¢/cup
2. Convection gas oven-cooking Salisbury Steak.		
Franklin (Bldg. 649)	834 Btu/serving	0.38 ¢/serving
Market Forge (Bldg. 665)	805 Btu/serving	0.36 ¢/serving
Franklin (Bldg. 657)	625 Btu/serving	0.28 ¢/serving
3. Ice Makers - ice cubes		
Scotman (Bldg. 649)	0.16 kWh/lb. ice	0.96 ¢/lb. ice
Manitowae (Bldg. 665)	0.18 kWh/lb. ice	1.08 ¢/lb. ice
Kold-Draft (Bldg. 657)	0.16 kWh/lb. ice	0.96 ¢/lb. ice
4. Frozen Food Cabinet		
Sub-Zero (Bldg. 649)	8.4 kWh/day	50.4 ¢/day
Sub-Zero (Bldg. 665)	4.2 kWh/day	25.2 ¢/day
Glenco (Bldg. 665)	15.5 kWh/day	93.2 ¢/day
5. Soda and Beverage Dispenser		
Cornelius Soda Dispenser (Bldg. 665)	3.0 kWh/day	18.0 ¢/day
Jet Spray's Beverage Dispenser (Bldg. 657)	2.4 kWh/day	14.4 ¢/day
6. Tilt Fry Pan (Bldg. 657-Groen)		
French Toast	0.04 kWh/serving	0.24 ¢/serving
Fried Chicken Steak	0.09 kWh/serving	0.54 ¢/serving
7. Deep Fat Fryer (Bldg 657-Vulcan-Hart)		
French Fried Potatoes	183 Btu/serving	0.08 ¢/serving
Southern Fried Chicken	791 Btu/serving	0.36 ¢/serving
8. Food Warming Cabinet (bldg. 657 - Franklin)		
Green Beans & Corn	0.04 kWh/serving	0.24 ¢/serving
Grits	0.025 kWh/serving	0.15 ¢/serving
9. Soft Ice Cream Maker Bldg. 645 - Taylor Freezer)	4.2 kWh/day	25.2 ¢/day

	Energy Consumed	Energy Cost
10. Steam Cooker (Bldg. 649 - Market Forge)		
Stewed Tomatoes	33 Btu/serving	0.015 ¢/serving
Cauliflower	41 Btu/serving	0.018 ¢/serving
11. Steam Jacket Kettle (Bldg. 649 - Legion Utensil)		
Macaroni & Chili	82 Btu/serving	0.040 ¢/serving
Vegetable Soup	65 Btu/serving	0.029 ¢/serving

III. ENERGY CONSUMPTION OF A DINING FACILITY

One dining facility at Fort Devens, Bldg. 649, was metered for total energy consumption. This metering included the consumption of electricity, natural gas, stem, and hot water by the dining facility (see Table 13). The collection of the total energy consumption data provides a reference point from which the operating efficiency of other dining facilities can be compared and evaluated (see Table 14). Corrective actions may be taken in those dining facilities which show high energy consumption rate.

The total energy consumed is an average of week days and weekends for a total of 42 days. The energy consumption was higher during the weekdays than on the weekends. This difference was chiefly because more meals were served during the week day (1500 meals/day) than served during the weekends (1050 meals/day). The steam used was entirely for cooking and operations. None of it was used for space heating.

Table 13. Average Energy Consumption per day in Dining Facility #649, Fort Devens

	Average Energy Consumption Per Day
Electricity, kWh	722
Natural Gas, cu ft	3226
Steam, lb	2219
Hot Water, gal	7696

Table 14. Comparison of Energy Consumption of Dining Facilities*

		Bldg. 649 Fort Devens	Bldg. 8402 Fort Lee**
1.	Electricity, kWh/meal	0.40	0.51
2.	Gas, cu ft/meal	1.80	1.29
3.	Steam, lb/meal	1.24	2.60
4.	Hot Water, gal/meal	4.57	5.46
5.	Average number of meals prepared and served per day	1,788	1,588
6.	Energy consumption, Btu/meal (no space heating)	7,870	9,782

*The comparison of energy consumption between the dining facilities was based on the total energy used for cooking and operating, not including the space heating.

**The energy data on Bldg. 8402, Fort Lee was taken from Technical Report NATICK/TR-79/032, K. H. Hu, J. Swift, G. W. Hudson, R. A. Lampi, and J. M. Tuomy. Quantitative Analysis of Energy Usage in Central Food Preparation System at Fort Lee, VA, June 1979. Bldg. 649 in Fort Devens and Bldg. 8402 in Fort Lee are of comparable size.

IV. CONCLUSIONS

1. Our data clearly show that a poorly kept and older item of equipment consumes much more energy than the one which is relatively new and well maintained. Also, indications are that a larger capacity equipment item consumed less energy than the smaller one, based on a unit of food or drink prepared.

2. Tilt Fry Pan has been observed to be one of the most versatile piece of equipment in the kitchen. Its energy consumption and energy costs deserve special consideration in light of its multi-usage capability.

3. The monitoring of total energy consumption (of a dining facility) could be a useful tool in determining the efficiency of managing a dining facility. As more energy data are collected, a standard could be established for military dining facilities in managing their energy usage.

V. RECOMMENDATIONS

1. It is recommended that, in the future testing of individual food service equipment items, testing be first conducted in the laboratory and then in a dining facility for a real-life evaluation. Testing conditions can be better controlled in the laboratory. Thus, the results can be used for comparison with the real-life evaluation so as to get an insight of
the equ
the equipment's capability.

2. The collection of total energy data for operating a military dining facility should be continued. The overall energy consumption is important in establishing an energy standard that can be used to assess how well a dining facility is managed in terms of energy utilization.

This document reports research undertaken at the US Army Natick Research and Development Command and has been assigned No. NATICK/TR-82/042 in the series of reports approved for publication.

VI. APPENDICES

APPENDIX A

DESCRIPTION OF EQUIPMENT

I. Building No. 649

a. Coffee Urn, twin, gas - 60,000 Btu/hr, 14-gal capacity, size 3, model C2174, Angelo-Colonna, Inc.

b. Oven, convection, gas - 60,000 Btu/hr, The Chef Line, Franklin Products Corp.

c. Ice Maker, cube, automatic, Scotman Model No. SB60, King-Seeley Thermos Co. Full capacity — 500 lb of ice.

d. Soft Ice Cream Maker, 2 compartments — 1 for vanilla, and 1 for chocolate ice cream. 5-gal capacity for each compartment. Model No. 777-27, Taylor Freezer.

e. Frozen Food Cabinet, Sub-Zero Model No. 2065F-G, inside dimension: 30" width x 55" Height x 21" depth, Sub-Zero Freezer Co.

f. Steam Cooker, 3 compartments (only 2 compartments are in operational condition), 266 lb/hr steam, Model 2W-2S, Market Forge.

g. Steam Jacket Kettle, 1-40 gal and 2-60 gal connected together with one shut-off valve to each kettle, Legion Utensil Co.

II. Building No. 665

a. Coffee Urn, twin, gas - 60,000/hr, 14-gal capacity, size 3, Model C2174, Angelo-Colonna, Inc.

b. Oven, convection, gas - 80,000 Btu/hr, Market Forge.

c. Ice Maker, capacity 250 lb of ice. Model AD040 2A, Type II, size 1, Grade A, Manitowac.

d. Soft Ice Cream Maker, Model 244, Sweden Freezer (due to the loss of gasket, this unit was not in operation during the data collection period).

e. Soda Dispenser, Model 31-6692, Series No. 31605 EA. Cornelius capacity 10 gal.

f. Frozen Food Cabinet, Model No. ALFA 48LT, Guardian XL, Glenco Refrigerator Co., inside dimension: 49" width x 60" height x 27" depth.

g. Frozen Food Cabinet, Sub-Zero Model 2065F-G, inside dimension: 30" x 55" height x 21" depth. Sub-Zero Freezer Co.

III. Building No. 657

a. Coffee Urn, twin, gas - 44,000 Btu/hr. Touch 'N Brew, 8-gal capacity. Model CR-66-G, Blickman, Inc.

b. Oven, Convection, gas - 60,000 Btu/hr. The Chef Line, Franklin Products Corp.

c. Ice Maker, capacity 450 lb of ice. Kold-Draft.

d. Beverage Dispenser, Jet Spray, 10-gal capacity.

e. Deep Fat Fryer, gas - 65,000 per hr, capacity 20 lb. Model No. 61944 Vulcan-Hart.

f. Tilt Fry Pan, Electric - 14.3 kW, Model FPC-4, Groen.

g. Food Warming Cabinet, Electric - 2,000 watt, twin compartment, Model 1262-P, Franklin Products.

APPENDIX B

Basis for Energy Calculation

1. **Unit Conversion**

   Electricity: kWh x 3,413 Btu/kWh = Btu

   Natural Gas: cu ft x 1,000 Btu/cu ft = Btu

   Steam: lb x 1,000 Btu/lb = Btu

   Hot Water: gal x 751 Btu/gal = Btu

2. **Energy Costs**

Electricity	6.0 ¢/kWh
Natural Gas	0.45 ¢/cu ft
Steam	0.45 ¢/lb
Hot Water	0.25 ¢/gal

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